LIVERPOOL SCHOOL OF TROPICAL MEDICINE

MALARIAL FEVER ITS CAUSE PREVENTION AND TREATMENT

BY

RONALD ROSS

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LIVERPOOL UNIVERSITY PRESS

Pools Containing *Anopheles* Larvae

From a photograph by Dr. Logan Taylor

LIVERPOOL SCHOOL OF TROPICAL MEDICINE

MEMOIR 1

MALARIAL FEVER

ITS CAUSE, PREVENTION, AND TREATMENT

CONTAINING FULL DETAILS FOR THE USE OF TRAVELLERS, SPORTSMEN, SOLDIERS, AND RESIDENTS IN MALARIOUS PLACES

BY

RONALD ROSS

F.R.C.S., D.P.H., F.R.S.

WALTER MYERS LECTURER

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Ninth Edition, Revised and Enlarged

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POOLS CONTAINING *Anopheles* LARVAE

From a photograph by Dr. Logan Taylor

M. D. Buckner

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PREFACE

This work is practically an enlarged edition of the *Instructions for the Prevention of Malarial Fever*, written by me some years ago, and published by the Liverpool School of Tropical Medicine. As many thousand copies of that little book were disposed of, it evidently met a public requirement ; and I am, therefore, encouraged to believe that a further exposition of the subject, including notes regarding the treatment of the disease as well as its prevention, will be not inacceptable to those who are called upon to reside in malarious countries.

The part dealing with Prevention is written chiefly for the use of the individual. Measures for the prevention of malaria on a large scale, as for instance by municipalities, are discussed in my work on *Mosquito Brigades*.

It should be added that most of the principles given here for the prevention of Malarial Fever will suffice for that of Yellow Fever and Elephantiasis—diseases which are communicated in the same manner.

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Malarial Fever

Its Cause, Prevention, and Treatment

Chapter I

MALARIA

I. Where the Disease prevails

MALARIAL FEVER is known under many other names. It has been called ague, paludism, marsh fever, jungle fever, and telluric fever. It also possesses many local names, such as African fever, Burma fever, Roman fever, and the like. All these denote the same thing.

There are two varieties of malarial fever, called intermittent fever and remittent fever. Malarial cachexia is the name given to the condition sometimes produced by very severe or prolonged malarial fever.

The disease is chiefly one of hot climates, but it often exists in the summer in temperate climates, and was once common enough in England, and even in Scotland. It is very prevalent in the tropics, where more than half the native children are sometimes found to be infected by it.

During many centuries, men have observed a

curious fact about the disease, namely, that it is usually most common in the vicinity of stagnant water. As a consequence of this law, it is also most prevalent in localities where stagnant water most tends to collect, as on flat plains, in mountain valleys, in the neighbourhood of estuaries, and so on. For the same reason, the most malarious time of the year is generally the rainy season.

Sometimes, however, fever is common in tracts which appear to be quite parched and waterless. But few countries are entirely without water, and it is to be observed that, in the driest places, human habitations are apt to exist just where there is some water.

Owing to this undoubted relation between stagnant water and malarial fever, the idea has taken root that the disease is caused by poisonous exhalations rising from the soil—especially from damp soil. Hence the terms malaria (bad air) and telluric (appertaining to the earth), which have been so frequently used. So strong has this fancy become, that people have even described outbreaks of fever as resulting from digging the soil, as if the telluric poison comes rushing out of the ground when its surface is disturbed. As a matter of fact, no proof of this idea has ever been given; and, indeed, we now possess the true explanation of the connexion between malarial disease and stagnant water.

It was formerly thought, too, that it is not a catching complaint, but we now know that it is so, provided that both persons—namely, the person who catches the disease and the person from whom it is caught—are living under suitable conditions. Thus, a man who enters a house or village where there have been many cases of malarial fever is very apt to acquire the infection there from the natives.

II. The Symptoms

Let us suppose that a person arrives in a malarious locality direct from England; then he will be subject to infection at any moment after his arrival. If he is a careless person, he may become infected the very first night he spends in the locality, but if he takes due precautions he may postpone the evil moment for years, or even altogether. Let us suppose, however, that he does become infected, and then let us trace in him the progress of the disease.

For a period of from about three to twenty days after infection, or even longer, he may remain apparently quite well. This is the *incubation period*, during which the poison is incubating in his blood. At the end of this time the illness commences—generally with a *headache* and feeling of being '*out of sorts*,' followed by a sudden *chill* accompanied by *fever*. The chill may sometimes be entirely absent, but at other times may be so severe as to cause a violent fit of shivering, called a *rigor*. Even when it is present the clinical thermometer shows that the patient's temperature is rising. In a few hours the temperature reaches 103-5° F., and the sick man complains of burning fever, and often of severe headache, nausea, or vomiting. This fever, varied by attacks of shivering or profuse sweating, may continue without intermission from a few hours to a week or more. The temperature then falls to normal (98·4° F.), or still lower (96-7° F.), and the patient feels much better; but the improvement is only temporary, for the fever now generally comes back with all its old violence, and attack follows attack, sometimes for weeks.

At the beginning of the illness the fever is generally continued for days, and is then called *remittent fever*. Later on it breaks up into isolated attacks of fever, each

lasting from a few hours to a day or two, and separated from the next attack by fever-free intervals. This kind of fever is called *intermittent fever*, and the intervals are called *intermissions*.

It often happens that the attacks of intermittent fever succeed each other with great regularity. When they come on every day, we have a *quotidian fever;* when they come on every other day, we have a *tertian fever;* and where they occur every third day, a *quartan fever.*

It was shown by Torti some centuries ago that a remittent fever is really nothing but an intermittent fever in which the successive attacks are so frequent or prolonged that, so to speak, they *run together* and produce a continuous fever. Most patients suffer at first from the remittent type of fever, which, after a week or more, tends to break up into the intermittent type.

We should here be careful to note that the symptoms may be much modified if the patient has been taking quinine. Large doses of this drug will generally cut short the succession of attacks; while moderate doses will shorten them and prolong the intermissions. Thus a patient who has been taking quinine as a precautionary measure may have only a few slight attacks of fever, in place of the severe illness described above.

If the patient cannot or does not take sufficient quinine, the progress of the case is often as follows :— After some weeks (if the patient lives) the fever goes away of itself, leaving the sufferer very weak and anaemic. It may be absent for weeks or months, during which he often flatters himself that he is cured ; but suddenly it comes on again as violently as before. This is called a *relapse*; and it is followed by another period of improvement called a *rally*. These rallies and relapses may follow

each other *for years*, even long after the patient has returned to a healthy climate, such as that of England.

If the patient is on the road to recovery, the relapses tend to become more and more slight, sometimes resulting in only a single short attack of fever. At other times, they may be alarmingly severe and may produce unconsciousness, or *blackwater fever*, or death. This is especially apt to occur if the patient has not obeyed his doctor's orders with sufficient care.

Relapses seem often to be provoked by such things as exposure to the sun, or chill, or fatigue, or other illness, or even indigestion ; but the fundamental cause of them is *the persistence of the malaria germs in the blood.*

If the attacks have been very severe or the relapses have been occurring for a long time, the patient often falls into the condition called *malarial cachexia*, which is characterized by an enlarged spleen, anaemia, indigestion, and a dusky complexion.

Blackwater fever is a peculiarly dangerous kind of relapse, found chiefly in intensely malarious localities such as parts of Africa and the Terai in India. The patient has generally high fever, with a great deal of vomiting. The urine becomes very dark in colour, sometimes almost black ; and there is usually considerable jaundice after a day or two. This condition rarely occurs except in persons who have neglected continuous treatment, and who have already suffered numerous ordinary attacks of fever. It is certainly dangerous, but by no means necessarily fatal ; and patients often have several successive attacks of blackwater fever, and yet live through them all.

III. The Germ

Such are the symptoms of malarial fever ; but what is the cause of the disease ? This was discovered by Laveran in 1880. Malarial fever is due to the presence in the blood of millions of minute microbes.

These little organisms are not bacteria, but are animal parasites. Each inhabits one of the red corpuscles of the blood, in which it lives just as a grub lives in a nut. Their size is less than the 1/2500th of an inch in diameter ; and I compute that something like a quarter of a billion of them must be present to produce fever. If they are sufficiently numerous, they can easily be detected by means of a powerful microscope in a small drop of blood obtained from a patient's finger. They are called *Haemamoebae*. Closely allied parasites are found in monkeys, bats, and birds.

Laveran, Golgi, and MacCallum discovered the leading facts about them. They propagate in the blood by forming spores. But there is this peculiarity about them, that all the *Haemamoebae* in a patient tend to produce their spores at the same time ; and it is precisely at the moment when the spores of all these millions of little creatures are scattered in the blood that the patient's fever begins. Afterwards, when the young spores occupy fresh blood corpuscles, the fever ceases for a time. But when the new generation is matured and forms spores in its turn, a fresh attack of fever occurs. This explains the periodical attacks which are so characteristic of malarial fever.

There are at least three kinds of *Haemamoebae* found in man. One forms spores every three days and causes quartan fever. Another forms spores every other day and produces tertian fever. The third kind is the usual cause of the severe, and sometimes irregular,

fevers of the tropics. Quotidian, or daily fever, may be caused by all the varieties, in a manner which cannot be discussed here. Patients often have two kinds in their blood at the same time.

These facts have been fully substantiated by the most careful investigations carried out by scores of scientific men in numerous countries. The literature of the subject consists of many hundreds of books and monographs.

The number of parasites in a patient varies from time to time. The more numerous they are, the worse as a rule is his fever. During the relapses, they are generally numerous enough to be found in a very small drop of blood; but when there has been no fever for some days, their numbers tend to diminish. But even when they cannot be found in a single drop of blood, we must not assume they have entirely died out of the patient. On the contrary, we are certain that they sometimes continue to live in a patient in comparatively small numbers for years—just as rats will live in a ship; and it is only when their numbers again increase to a quarter of a billion or more that another relapse comes on. When complete recovery occurs the parasites die out entirely; and this sometimes happens spontaneously.

Some patients seem to become so accustomed to the presence of the parasites that they cease to suffer fever or other illness in consequence of them. This is especially the case with native children. Koch, Daniels, and others found that more than half the negro children in parts of Africa contain the parasites and yet appear to be quite well. Nevertheless, though these children do not themselves suffer much, they are the principal source of infection for others. When the children reach puberty the parasites tend to die out in them completely by some natural but unknown process.

A skilful microscopist will not only find the parasites in blood taken from a patient's finger, but will be able to detect at sight the species to which it belongs, the stage of progress which it has reached, and even its sex—for, in a certain sense, even these minute animals undoubtedly possess sex. It is easy, then, to verify the frequently recorded observation that the parasites largely decrease in number after the patient has been given a considerable dose of quinine. Indeed, we can state it as a fact—though we cannot quite explain the fact—that *quinine kills the parasites.*

IV. How Parasites in General are Communicated from one Host to Another

All plants and animals possess parasites, and thousands of different species of parasites have been closely studied by science; we therefore know much about their general ways of life. As a rule, a particular species of parasite can live only in the particular species of animal in which, by the evolution of ages, it has acquired the power of living. It is therefore not enough for the parasites of an individual animal—say a man—to be able to multiply within that individual, but they must also make arrangements, so to speak, for their progeny to enter into and infect other individuals of the same species. They cannot live for ever in one individual; they must spread in some way or other to other individuals.

The shifts made by parasites to meet this requirement of their nature are many and various, and constitute one of the wonders of nature. Some scatter their spores and eggs broadcast in the soil, water, or air, as it were, in the hope that some of them will alight by accident on a plant or animal suitable for their further growth. Many

parasites employ in various ways a second species of animal as a go-between. Thus, some tape-worms and the worms which cause trichinosis spend a part of their lives in the flesh of swine, and transfer themselves to human beings when the latter eat this flesh. To complete the cycle, the parasites return to swine from human offal; so that they propagate alternately from men to swine and from swine to men. The blood parasites which cause the deadly tsetse-fly disease among cattle in South Africa, are transferred from one ox to another on the proboscis of the ox-biting tsetse-fly. The progeny of the flukes of sheep enter a kind of snail, which spreads the parasites upon grass. The progeny of the guinea worm of man enter a water flea. The progeny of *Filaria nocturna*—the worm which produces elephantiasis—live in the human blood. When certain kinds of mosquitoes suck this blood, the young worms take up their quarters in the insect and burrow their way into the proboscis. When the insect, some weeks later, bites another man, they work their way from its proboscis into his skin, and then complete their development in him. At least such is inferred to be the case from the strongest circumstantial evidence. The progeny of the parasites which cause Texas cattle-fever—and which are very like the malaria parasites—live in cattle-ticks, and are transferred by the young of these ticks into healthy cattle. Lastly, we have just discovered by the most conclusive experiments that the dreaded disease, yellow fever, is carried from man to man by a brindled kind of mosquito called *Stegomyia*.

All these are not theories or fancies, but hard facts, won by science at the cost of immense labours carried out by many scientific men during many years.

V. How the Parasites of Malaria pass from Man to Man

Like other parasites, those which produce malarial fever, the *Haemamoebae*, must be able to spread from one man to another. How do they do it?

Noting the connexion between malarial fever and stagnant water, referred to in section I, many people thought that the parasites must come from the soil or water. But all efforts to find them in soil or water proved unavailing; and at one time it seemed probable that the great problem as to how men get malarial fever would remain unsolved for years. Fortunately, in 1883 and later, four distinguished men, King in America, Laveran in France, Koch in Germany, and, especially, Manson in England, suggested that the mosquito carries the disease. Working at the problem from this point of view, by dissecting mosquitoes fed on malarial patients, I succeeded, between 1895 and 1899, in demonstrating that *the parasites of malaria found by Laveran pass a hitherto undiscovered stage of their existence in mosquitoes, and are then inoculated into our skin by the bites of the insects.*

The story is briefly as follows:—When a mosquito bites a malaria patient, it sucks up a number of malaria parasites with the patient's blood. The parasites burrow into the insect's tissues, grow rapidly, and, after a week or two, produce a number of spores. Most remarkable to relate, these spores enter the *poison* or *salivary gland* of the insect. This gland secretes a minute drop of fluid, which the insect injects through its proboscis into our skin when it bites us, and to which the itching produced by the bite is due. The spores of the malaria parasites actually lie in this fluid and are injected with it

into our skin, where they mix with our blood and produce infection.

Thus the mosquito acts in regard to malaria almost precisely as it acts in elephantiasis. It takes up the germs from a patient, and after a week or two puts them into the blood of a healthy man.

All this may appear to the unitiated reader to be too wonderful for credence; but it is absolutely and certainly true. Every stage of development of the parasites in the mosquito has been followed over and over again by the most careful and exacting microscopists; and, I may add, the dissection of mosquitoes and their examination by modern microscopes is not so difficult a task as some may think. But, apart from the microscope, there is a method of obtaining a crucial proof of the whole matter—by actually producing the disease by means of mosquitoes. This was done by me in 1898, when I infected twenty-two out of twenty-eight healthy sparrows by mosquitos previously fed on diseased sparrows. Subsequently, healthy men have been infected in precisely the same manner. Thus, in 1900, Manson infected two gentlemen in the middle of London by mosquitoes brought from the Campagna in Italy; and similar successful results have been obtained by Ziemann, Fernside, and Bignami. The whole work has been confirmed and amplified by Koch, Daniels, Christophers, Stephens, Bignami, Bastianelli, Celli, Zieman, Ruge, Gosio, Van der Scheer, Van Berlekom, Thayer, Woldert, Fernside, Annett, Ould, Dutton, Nuttall, Shipley, and others; has been fully accepted by such authorities as Lord Lister, Koch, Laveran, Metchnikoff, Sir Michael Foster, Ray Lankester, Osler, Blanchard, Mesnil, Lühe, and others; and has lately received circumstantial confirmation by the discovery of the fact that yellow fever is communicated in the same way.

VI. Some Additional Information

During the last three years investigations made in many parts of the world have given the following results :—

1. Up to the present, the parasites of human malaria have been found to develop only in mosquitoes of the kind called *Anopheles*. Even of these, not all species appear equally receptive, because one at least, namely, *Anopheles rossii*, does not seem to harbour the germ easily. *Anopheles costalis* and *Anopheles funestus* are known to carry the parasites in Africa; *Anopheles maculipennis* in Europe and the United States; and *Anopheles culicifacies* and two other species in India.

2. Up to the present, *Anopheles* have always been found where fresh cases of malaria are occurring, and where the facts have been properly investigated by competent persons.

3. The germs have been frequently found in a large percentage of *Anopheles* caught in infected houses; and occasionally even in *Anopheles* caught in the bush. In the latter case it is assumed that the insects became infected by having previously bitten villagers living in the neighbourhood.

4. The germs have never been found in mosquitoes captured in the larval stage, and examined before being fed on infected persons. For this and other reasons it may be assumed that *Anopheles* can become infected only by biting infected people.

5. The kinds of mosquitoes called *Culex* and *Stegomyia* always proved negative in my Indian researches; in those of Daniels and others in Africa; and in those of some Italian writers who followed my work. At the same time, we are not yet quite

certain that some species of mosquitoes other than *Anopheles* cannot carry human malaria.

6. The principal facts connected with the habits of mosquitoes as they affect the malaria question, were made out by myself in India, and by Annett, Austen, and myself in Sierra Leone; but many important details have been added by Daniels, Christophers, and Stephens in Africa and India, Howard in the United States, Nuttall and others in England, and Strachan, Annett, and Dutton, and others, elsewhere. The anatomy of mosquitoes has been minutely studied by Christophers, Nuttall, Shipley, Dutton, and others.

7. In 1900, Manson infected two gentlemen in London by mosquitoes brought from Italy, and at the same time kept several free from fever in a mosquito-proof house, in the most deadly part of the Campagna; thus giving a most striking demonstration of the facts cited above.

8. The Liverpool School of Tropical Medicine has made a detailed survey of the malaria question in West Africa, by sending out numerous experts to that region.

9. Nuttall, Cobbett, Shipley, and Strangeways-Pigg have studied *Anopheles* in Britain and their relation to former malaria in this country, and their preference for certain colours. Laveran has studied the malaria question in France.

10. Koch has demonstrated the feasibility of reducing malaria in small settlements by searching out all cases of the disease, and subjecting them to rigorous treatment by quinine.

11. Young, Thomson, Doty, and others, have reduced malarial fever in localities in Hong Kong, and near New York, and elsewhere, by draining the breeding places of *Anopheles*. Sir William MacGregor and the

Hon. Dr. Strachan are dealing with the disease on a large scale in Lagos. Dr. Logan Taylor and myself (Liverpool School Expedition), with the assistance of the governor, Sir Charles King Harman, are undertaking the reduction of mosquitoes in Freetown, Sierra Leone, with a considerable degree of success already obtained. In Havana, the chief sanitary officer, Major Gorgas, during 1901, has entirely banished yellow fever, reduced malaria by one-half, and diminished the number of mosquitoes by 90 per cent. approximately. Much work of the same kind is said to have been done in Italy.

All these laborious investigations have resulted in giving us a very complete and exact knowledge of malarial fever; so much so that we can now, generally, both prevent and cure the disease with something like certainty. Thus for example, of the numerous scientific men who have been studying the disease for years in the most deadly places, nearly all have escaped anything like serious illness, and most have escaped infection.

It is necessary to add here that as soon as the difficult problem regarding the exact mode in which malarial fever is propagated was solved, a number of foreigners made the usual efforts to pirate the whole discovery. As a matter of fact the problem was solved solely and simply by my researches of 1895-9, based upon the profound inductions of Manson and Laveran. Koch and Daniels were the first to confirm my work by really honest and reliable researches.

The relation between elephantiasis and mosquitoes was discovered by Manson more than twenty years ago; but quite recently Low, under Manson's guidance, and James in India added a most important fact.

The relation between yellow fever and mosquitoes was discovered by Finlay, Reed, Carroll, Lazear, and Agramonte.

VII. Some Objections Answered

Of course, in order to understand this great subject thoroughly, it is necessary to study carefully the original reports, with all their scientific drawings ; and even to examine specimens under the microscope. It is only natural then that those whose information is merely derived from newspaper reports and so on should lie under many misapprehensions in regard to the matter.

One of the first difficulties which the reader will feel arises from the conflict between the old ideas and the new. The telluric theory of malaria—the superstition that the disease is due to a poisonous exhalation from the soil, or to a miasma rising from marshes—has obtained, during several centuries, such a grip on the public mind, that it is not likely to disappear for many years ; and people will long dread the harmless smell of turned earth, or point with fear to the innocent evening mist, or close their windows against the cool evening breeze. Yet all these ideas never amounted to anything more than a guess —a conjecture based on the known relations between malarial fever and stagnant water. It is true that malaria is connected with stagnant water ; but this does not prove that the infecting principal rises in the form of a mist. This is nothing but a mere fancy of our forefathers. No one has ever found the germs of malarial fever in water or the soil. On the contrary, Calandruccio, Zeri Agenore, Celli, and others have frequently tried to cause infection in healthy persons by water, earth, and air brought from intensely malarious localities, and have always absolutely failed. Besides this, the idea that the malaria germs diffuse themselves in the air is contrary to all we know of the habits of animal parasites ; it is contradicted by an observation which has frequently been made that, of

two houses a few yards apart, or even of the two sides of a barrack or hospital, one may be malarious and the other not so ; and, lastly, it cannot be reconciled with the fact which has been conclusively demonstrated that wire gauze screens to the windows (through which the air can enter freely) suffice to exclude the infecting principle. Again, the idea that the germs wait in the soil ready to pounce upon anyone who comes and digs in it is equally fabulous. No one has ever given adequate proof that, *ceteris paribus*, agriculturists are more subject to the disease than other men are. On the contrary, in many localities, native babies in arms are the most frequent victims.

But there is no longer any reason at all why we should suppose that the infection of malaria rises from water or the soil. The connexion between malarial fever and stagnant water is now fully explained in another way. *It is not the germ which rises from stagnant water; it is the carrier of the germ which does so.* The *Anopheles* mosquitoes which carry the parasites from man to man *breed chiefly in stagnant puddles of water on the ground.*

I trust that the reader will see the full force of this remark. Malarial fever exists in the neighbourhood of stagnant water for one simple reason—because the kind of mosquitoes which carry the infection breed in such water. Not because of any miasma or mist which rises from the water.

How exactly the new discovery fits in with the experience of centuries may be judged from the fact that not all kinds of mosquitoes breed in puddles on the ground. It is chiefly the *Anopheles* which do so. The commoner kinds, called *Culex* and *Stegomyia*, breed mostly in tubs and pots of water. If malarial fever had been carried by these kinds of insects, it would not have

been specially connected with stagnant water on the ground—at least in the tropics.

In fact the word *malaria* (bad air) is now known to be a misnomer. We continue to employ it only because it is in general use. Perhaps the old name Ague would be a better one.

We shall now proceed to discuss other objections. It is often said that attacks of ague may occur without the patient being previously bitten by mosquitoes—as, for instance, in England in the depth of winter. But, of course, it is only the *first infection* which is produced by mosquitoes. The insect merely puts the germ into the blood ; subsequently, as described in sections II and III, the germs may cause relapses of fever for years, wherever the patient may happen to live. The *relapses* need not necessarily be preceded by mosquito bites.

But some people continue to insist that even their first attack of ague was not preceded by mosquito bites. Here it must be said that while some people feel mosquito bites acutely, *others never notice them.** A friend of mine once told me that mosquitoes never touched him ; yet while he was talking I found numbers of freshly-gorged mosquitoes in his bedroom, in which he had been sleeping without a mosquito net. Another man told me that there are no mosquitoes in Sierra Leone ! It must be remembered that mosquitoes are really nothing but gnats, that they abound almost everywhere in the tropics, and that, except when special precautions are taken, almost everyone is stung by them several times a day. At night, of course, many people sleep calmly through the attacks of dozens of mosquitoes without feeling them at all. When, therefore, we

* It is possible, however, that some persons are really little bitten by the insects ; but this statement requires proof.

remember that the bite of a single gnat may produce a malarial infection which may cause attack after attack of fever for years, we shall not be inclined wholly to credit such statements as are referred to above.

It is certain, however, that malaria may be very virulent in localities where there appear to be very few mosquitoes. Now, the mosquitoes which are generally most in evidence—which hum and hover about one, and sit on the walls in the day time—are the common kinds called *Culex* and *Stegomyia*. The *Anopheles* are much more direct in their methods; they seem to hum and hover less, and often visit a house only in the hours of darkness. Hence a house may be apparently almost free from mosquitoes, when in reality it is visited nightly by numerous mosquitoes of the kind which carry malaria. An instance of this was noted by Dr. Strachan and myself in a railway house at Ibadan, near Lagos in Africa. During two days no mosquitoes were seen, and only one or two heard humming in the evening; and we should never have believed that so many *Anopheles* came to the house at night did we not find no less than five of them caught inside an old mosquito net used by a native servant. The net was full of holes, and the insects had entered during the night and could not escape in the morning. If we ourselves had not used well-made nets we should probably have been bitten during sleep by dozens of *Anopheles*, without seeing one of them. If one of these had been infected, we should have acquired malarial fever without knowing how. This is just the way in which many people become infected in localities where mosquitoes seem to be very rare. It must be remembered too that, with some people, the bite of the mosquito leaves no mark—at least after an hour or so.

It used to be often thought that malarial infection

can be acquired in uninhabited places. There is no clear evidence of this. To reach an uninhabited place now-a-days one has to travel through hundreds of miles of inhabited country, and to live in rest-houses, camps, and native villages, in all of which the disease may be contracted. Sportsmen sometimes say that certain spots are so deadly that they acquired fever the moment they arrived there. This only proves that the infection was really acquired elsewhere, since there must be an incubation stage of at least three days between the moment of infection and the onset of fever. These and many other stories told by travellers seldom bear scrutiny. Of course, infected mosquitoes may wander some distance from villages and then bite travellers in the bush.

It has been thought possible that *Anopheles* may sometimes pick up their infection from monkeys and bats, which contain parasites almost identical with the malaria parasites of man ; but the subject has not yet been adequately studied.

People sometimes ask whether other insects besides mosquitoes, such as sandflies, carry malaria. Ziemann's experiments with sandflies were negative ; and there is little to be said in favour of other flies possessing such a function.

Many people think that gnats live only for a day or two, and hence feel inclined to doubt statements to the effect that the malaria parasites can exist in them for weeks. As a matter of fact, mosquitoes have been kept alive in test-tubes for two months and more, and it is known that they can live all through an English winter. A single mosquito can remain infective for several weeks, during which it can probably infect several persons.

People often ask the following question. If

mosquitoes obtain the parasites from men and men from mosquitoes, where did the parasites first come from? This is like the question: If the hen comes from the egg and the egg from the hen, which began first? All we know for certain is that the parasites do alternately occupy men and mosquitoes. We cannot say how it was they commenced to do so. But science has hazarded an explanation based on the theory of evolution; to the effect that all parasites were ages ago free living creatures which later found it to their advantage to become parasites first in one species of animal, and then in a second species closely connected in habits with the first. But this is a zoological question.

It sometimes happens that a considerable amount of fever may break out amongst a number of men, as in a regiment on service, or in a gang of workmen, or in a travellers' convoy. This may be due to fresh infections caused by mosquitoes; but the fever may sometimes be nothing else but relapses due to fatigue, or to cold weather, or to bad diet. This explains many outbreaks which occur in dry localities or during the winter months.

In the tropics most natives and many old residents constantly have the malaria germs in small numbers in their blood, and consequently suffer from relapses on small provocation. I have frequently seen Indian soldiers, who had enjoyed excellent health in barracks, go down with fever in large numbers a day or two after starting upon a march.

Owing to facts like these, and also to the manner in which *Anopheles* are apt to be overlooked even when in large numbers, it is often a difficult matter, requiring the full knowledge of an expert, to decide what is the cause of a given outbreak of fever. The airy confidence of the amateur who attributes the sickness to any marsh

which may lie within ten miles of the place is not always to be trusted.

It often happens, too, that the fever *is not malarial fever at all.*

Lastly, the reader must be warned against accepting everything that is told him by people who have lived long in the tropics and imagine that they know all about malaria. Such people often oppose recent discoveries without really understanding much about them. They are apt to think too that a mere expression of their disbelief is quite enough to upset all the conclusions of science. But if they really have anything to say worth saying, their best course is obviously to publish the matter in some scientific journal, where it will receive what attention it deserves. The people who are to be most trusted in this matter are the experts who have made it the principal study of their lives.

LARVAE OF *Anopheles* FLOATING ON THE SURFACE OF A BOWL OF WATER, AND SEEN FROM ABOVE.

From a photograph by Dr. C. W. Daniels.

Chapter II

MOSQUITOES

VIII. A Brief Account of Mosquitoes

Mosquitoes are the same as gnats. In temperate climates, gnats are troublesome only during summer, and even then are much excluded by glass windows. In the tropics, however, where the climate is hotter than our summers and where windows usually stand open day and night, gnats become very troublesome indeed, and have therefore acquired the special name, *mosquito*. It should be understood however, that in structure and appearance the mosquitoes of the tropics are precisely the same as the gnats of temperate climes.

Many hundred *species* of gnats are known to science, and these are grouped by entomologists in numerous *genera*. The whole family of gnats is called *Culicidae*. The only genera which we need refer to here are the genera, *Culex*, *Stegomyia*, and *Anopheles*. Many books have been written on the subject.

Gnats, like other insects, possess three stages of life: the *larva* or caterpillar, the *pupa* or chrysalis, and the *imago* or winged adult.

The *eggs* are laid by the adult female on the surface of water. Here they soon hatch out into larvae.

The *larvae* of gnats are the little creatures which are so frequently found in tubs of water, and which

are popularly called *wigglers* or *wrigglers*, owing to their peculiar movements. They live *only in water*—tubs, pots, puddles, ponds, and small streams. Complete drying kills them, and they do not exist in grass or trees as some people imagine. Hence mosquitoes cannot *breed* without water; though the adult insects can live without water for months in dense undergrowth—a fact which gives rise to the idea that they breed in grass. The duration of the aquatic larval stage varies from about a week in hot climates to months in a cold one. The food consists of waterweed, animalculae, and—other larvae. Fish, water beetles, and tadpoles prey upon them.

The larvae cannot breath under the water like fish, but must frequently come to the surface for this purpose. The air is drawn in through an orifice near the tail—which explains why these creatures so often rest hanging head downward from the surface of the water.

The *pupa* or chrysalis is very like the larva, with a *hood on it.* It also floats on the surface; but on being disturbed wriggles downward. This stage lasts a day or two in hot climates.

The *imago* or winged adult rises from the pupa and remains standing upon its shell for an hour or so, until its wings are grown and dried. It does not live for only a few days, as was supposed, but for months. I have kept mosquitoes alive for more than a month in test tubes in India, in 1898; and since then they have been kept for more than two months in the same manner. They are known to live through the winter in Europe in cellars, closets, and stables. Both sexes feed on fruit; but the females—and as a rule the females only—suck blood from men, animals, and birds. The proboscis, which is the organ of the insect used for this purpose, consists of a sheath in which a number of sharp prickers

or *stylets* are kept encased when not in use—to be plunged into the skin when required. Before commencing to suck, the insect injects into the wound, through one of these stylets, a little drop of saliva ; and it is this saliva which causes the irritation of the bite, and which also carries the spores of the malaria parasite.

It takes one or two minutes for the female to fill herself with blood ; but this does not content her, and she can go on biting all through the night. In the morning she is gorged, and generally goes to sleep in some dark corner of the house. After two or three days her meal is digested, and, her eggs being now matured, she flies to some suitable stagnant water to lay them in. This done, she returns to have another feed, and finally to lay some more eggs, and so on indefinitely. In my experience it is necessary to the female to have a meal of blood before laying eggs. So far as we know, a female mosquito may live for a year, if she be not eaten by some spider, bat, or bird, or killed by some tormented human being. She shows great pertinacity in her attack, returning to the charge again and again, and exploring every inch of clothing to find a suitable place for boring operations. She can sometimes penetrate through two layers of linen, but usually finds a difficulty with regard to flannel, owing to its hairiness. In the night she will explore the whole of a mosquito net which contains a sleeper, and will assuredly find out the smallest rent or hole. It is easy to see how admirably adapted creatures of this kind, which during their life may bite some dozens of different people, are for carrying about the germs of various diseases from one victim to another.

The male mosquitoes seem to feed only on fruit, and are probably not so long lived. They can be immediately distinguished by the *feathered antennae* on their

heads. Observations have been cited by Mayer, Weaver (quoted by Howard), Brennan, and Maxim, showing that the males are attracted by the musical note produced by the female.

In my opinion the 'song' of the mosquito is probably produced by the vibration of the insect's wings, because I observe that it always ceases the moment the wings come to rest.

Mosquitoes contain many kinds of parasites. Besides those of malaria and elephantiasis, and many bacteria, I found five kinds of animal parasites in them in India; and also frequently saw ticks adhering to their skin.

The zoology of mosquitoes has been carefully studied of late by Ficalbi, Howard, Austen, Giles, and particularly by Theobald; the minute anatomy, by Christophers, Nuttall, Shipley, Dutton, and others.

As a rule mosquitoes breed close to the houses where the adults find their human food. The idea that the insects are carried in by the winds from distant marshes has little evidence in its favour. As a matter of fact, directly a strong wind begins to blow the insects tend to take shelter. In most cases where mosquitoes are plentiful in a house, they are being bred in tubs or puddles just outside the windows. Sometimes, however, in places surrounded by thick bush, it is difficult to find their breeding pools; and where they cannot get food nearer they will travel perhaps half-a-mile from their haunts for it. But the popular notion that the insects are uniformly diffused all over the tropics, like the air we breathe, is absurd. Like other animals, mosquitoes tend to be strictly local in their habits; and to abound most where they can the most easily find food, shelter, and stagnant water for themselves and their larvae. The proof of this is that, of

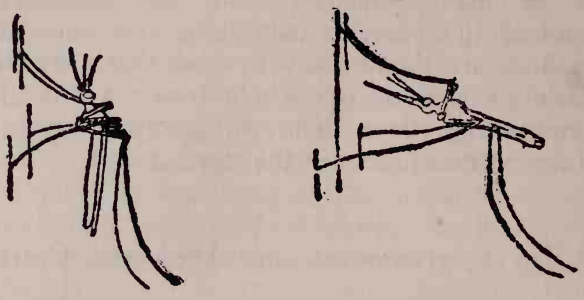
two houses a few yards apart, swarms of mosquitoes may be found in one and few in the other. It is, indeed, just this fact which leads unobservant people to make so many mistakes about the prevalence of mosquitoes in a place; a man living in a house where mosquitoes are numerous will think that they abound similarly throughout the whole town; another living in a house free from them will go away saying that there are no mosquitoes in the town at all!

IX. Culex, Stegomyia, and Anopheles Compared

The kind of mosquitoes called *Culex* generally have plain legs and wings, and a clumsy body. When seated on a wall, their bellies approach the surface of the wall. They are found almost everywhere; and *Culex pipiens* is the common English gnat. They bite chiefly in the darkness, and sleep in the daytime. Their larvae live principally in tubs, flower-pots, cisterns, drains, and ditches, and sometimes also in puddles, and even small streams. These larvae possess a long breathing tube near the tail, by means of which they hang suspended head downward from the surface of the water. When disturbed they wriggle immediately to the bottom. This kind of mosquito carries the parasite of elephantiasis.

The kind called *Stegomyia* is somewhat like *Culex*, and is well known as the *brindled* or *tiger mosquito*. Its shape and attitude when seated on a wall are like those of *Culex*, but it frequently carries its last pair of legs tilted on its back. Its wings are plain, but its legs are profusely barred. It bites much in the middle of the day, and is very voracious. Its larvae possesses much the same attitude and appearance as *Culex* larvae, but are, perhaps, more confined to vessels of water, especially

pots, broken bottles, empty food-tins, tin-lined packing cases, tubs, and, indeed, all places where a little rain-water can collect. It carries yellow fever.



Culex *Anopheles*

Mosquitoes Resting on a Wall

The kind called *Anopheles* varies considerably from the foregoing. It has a more elegant body, and, as noted by Strachan, a straight body axis. The wings are generally spotted. The proboscis is long and thick. The attitude, when the insect is seated on a surface, is different ; the body projects away from the surface at an angle, the head being nearest to the surface and the extremity of the tail furthest from it. The larvae have no elongated breathing tube near the tail, and float flat on the water like sticks. When disturbed they 'skate' with a backward jerk on the surface, before diving to the bottom. They are often so delicate that it is difficult to see them at all unless a white jug or plate is used for collecting them. *Anopheles* bite chiefly in the darkness, and carry both malaria and elephantiasis ; but *A. rossii* of India is negative as regards malaria.

One of the most important points about this kind of mosquito is that its larvae breed mostly in pools of water on the ground, and seldom in vessels of water.

They do not, however, frequent all pools, but mostly those which are not so large as to contain minnows, nor so small as to dry up within a week or so, and which are not liable to scouring out during heavy rain. Such pools abound in flat, marshy country, in valleys, on the margin of lakes and rivers, in forests, on badly-drained roads, and in unkempt back yards; and it is for this reason that these places are often so malarious. The larvae are also found in the rushes at the margins of ponds and even rivers, in small weedy streams and ditches, in old wells and borrow-pits, in hollows in rocks filled with rain, in pits and pools by the side of railway and road embankments, in pools in drying watercourses, and sometimes in tubs and the bilge-water lying in boats and canoes. In marshes, they exist rather in the small pools at the margin than in the open flats of water.

Anopheles abound in forest, bush, and open country covered with scrub—in all of which they feed on villagers, animals, and birds, and attack travellers in camps or rest-houses. A small proportion are found to contain the germs of malaria even away in the open country. But in and near the houses of natives, whose children so frequently contain the germs, a very large percentage of *Anopheles* are often infected; so that a traveller sleeping in or near native villages always runs a grave risk.

As already mentioned, *Anopheles* do not hum and hover round their victims as much as other kinds of gnats do; and, as they often enter houses only at night, they are apt to be so little perceived that, even where they are most numerous, people will go away saying there are no mosquitoes in the place at all.

X. How to Get Rid of Mosquitoes

We can protect ourselves from mosquitoes by mosquito nets and wire gauze screens to the windows, as described in sections XII and XVI. Many *culicifuges*, that is, substances to be rubbed on the skin for the purpose of driving away the insects, have been vaunted, but none of these have yet proved entirely reliable. In many cases we can certainly obtain much relief by getting rid of the insects themselves.

A good plan is to order a native servant to go round the house early every morning and kill every mosquito he sees. The insects can be killed on the wall by means of a fly-flapper, or caught in a small butterfly net and then crushed. If there has been any fever recently in a house this should always be done.

Another way to kill the adults in a house is to shut up all the windows and doors and burn some 'culicicide' inside. Sulphur lighted in a brazier or small flower pot or galley pot, put standing in a basin of water, is perhaps the best substance. Horticulturists use many patent chemicals in this manner for destroying 'green fly' and other pests in conservatories. I have heard that coarse, damp brown paper placed in a large tin and mixed with a little tobacco and burned, is very effective. One of the best culicicides is pyrethrum powder, bought from the druggist, damped and made into a small cone, and then dried and lighted at the top (Howard). The smoke kills the insects—as most kinds of smoke appear to do. Gorgas extirpated yellow fever from Havana, in 1901, by destroying all mosquitoes with pyrethrum in infected houses and the neighbouring ones.

As a rule however, instead of destroying the winged insects, it is easier to attack the helpless larvae

living in water ; or, still better, to do away entirely with the stagnant water in which only they can breed.

The simplest way to kill the larvae is to throw them out of the vessel, with the water in which they live, upon the dry ground ; or, when they are in puddles, to brush them out with a broom. The ground absorbs the water and the larvae quickly perish.

If, however, the insects are found in water which is required for domestic purposes and cannot be wasted, as in cisterns and tanks, or in water which cannot be emptied out, as in wells and large pools, another method must be adopted. This consists in pouring a little *thin oil* on the surface of the water. The oil forms almost immediately a fine film over the whole surface and *prevents the larvae breathing*.

Ordinary paraffin oil or kerosine is most commonly used ; but crude petroleum and the cheapest and coarsest oils in the local market often do better. I advise the reader to make some experiments for himself with the cheapest oils he can procure. He should see that enough oil is used actually to kill the insects, and should, of course, use an oil which forms a film and which does not merely produce one or two globules in the water. For pools of water it is advisable to jerk the oil upon the surface, or to 'paint' it on with a rag tied to a stick. Oil has long been used on a large scale for this purpose in the United States, and is being employed in Havana and Sierra Leone.

For drinking water, eucalyptus oil is good, because after killing the larvae it evaporates and leaves no taste in the water. Kerosine may be used for cisterns from which the water is drawn by a tap.

Still better than destroying larvae is the removal of their breeding places. All old flower-pots, broken bottles, and empty tins should be collected in a dust-bin ;

old tubs should be broken up, small puddles should be drained or filled up with stones and gravel ; drains should be made good, gutters on the roof should be seen to, and so on.

The householder should go round his house and garden once a week and look into every place likely to harbour larvae. Of course the water must stand for at least a week before it will breed mosquitoes ; and such water must be removed or treated with oil at the weekly visit.

In my experience, if all the stagnant water is removed from the premises, the adult mosquitoes inside the house—which must have water to drink and lay their eggs in—soon fly away to the premises of more hospitable neighbours.

It is, in my opinion, possible to rid a whole town of mosquitoes by adopting concerted action against them. It is necessary to employ a sufficient gang of men constantly for the purpose of collecting old tins and bottles, etc. ; draining and filling up pools and marshes ; and 'training' the banks of streams and large bodies of water. In large towns in the tropics this should be done by the municipality ; and I have been urging the measure on British Colonial Governments for some years. It is obvious that if in a town which contains, say, a thousand breeding places of mosquitoes, we reduce these to one or two, then we shall also reduce the total number of mosquitoes in the place by a large percentage. Of course a few insects may wander into the town from outside, and a few may continue to breed in collections of water, such as wells and large lakes, which we cannot get rid of ; but these facts need not prevent us from putting a stop to the proliferation of the insects as much as we can within the area with which we are dealing.

As Dr. Harford-Battersby says in *Climate*—'To

say that because we cannot get rid of all mosquitoes we should not attempt to get rid of any, is like saying that because we cannot hope to capture all burglars it is no use for the police to arrest any of them, as others may come to take their place.' Mr. Howard, Entomologist of the United States Department of Agriculture, says in his book, *Mosquitoes*—'After a number of years' experience in fighting mosquitoes, the present writer has come to the conclusion that there is no reason why any community should submit to the mosquito plague.' He adds that at first he thought this would be possible only in places where the source of the mosquito supply is circumscribed; but that he now thinks it possible anywhere where the people take the necessary trouble. Such has been my opinion for years; but it is unnecessary to discuss the question *a priori*, since the thing has actually been done. In Sierra Leone, Dr. Logan Taylor and Dr. Daniels report that much success has been obtained in this line; and in Havana, Major Gorgas estimates that on an average mosquitoes have been reduced by ninety per cent. There is, therefore, no longer any excuse why municipalities should not keep the towns in their charge properly drained and cleaned; and if in such towns the reader is much pestered by insects coming from outside his own premises I advise him to write and complain.

Apart from the mischief they cause as carriers of disease, mosquitoes are also a terrible plague in the tropics; and every effort should, therefore, be always made to get rid of their breeding places wherever possible. Thus small settlements of Europeans can always afford to keep two or three intelligent native workmen continually engaged on the job; and even single isolated factories can generally do the same thing. It is astonishing how much in the way of draining and

filling up pools and of generally cleaning a place can be done even by a few men when kept constantly at work. As a rule a native workman costs only twelve pounds a year, or even less.

For full details regarding concerted action against malaria and other mosquito-borne diseases, as apart from mere personal precautions, the reader should see my little book, *Mosquito Brigades; and How to Organise Them.* The book contains a full account of the actual work done in Hong Kong, New York, Lagos, Havana, and Sierra Leone.

Chapter III

PREVENTION

XI. Preventive Measures

We have seen then that the following facts have been conclusively proved:—

1. The malarial infection is carried from the sick to the healthy by certain kinds of mosquitoes. The insects become infected by biting patients with parasites in their blood, and after a week or two are able to inoculate the poison into the blood of those whom they may subsequently bite.

2. In the tropics, the insects generally become infected by biting native children. After being infected they live about the neighbourhood for weeks or months, biting fresh persons every few days.

These discoveries at once enable us to adopt a number of effective preventive measures against infection from malarial fever in malarious places. The same measures (with the exception of the use of quinine) are effective against yellow fever and elephantiasis. They are as follows:—

A. **Personal Precautions** to be adopted by *Everyone—Everywhere*:—

1. The habitual use of mosquito nets.
2. The occasional use of quinine.
3. Use punkahs and electric fans as much as possible.
4. Avoid sleeping in the houses of natives or near native villages as much as possible.

B. **Domestic Precautions** to be adopted in *Private Houses*, *Factories*, *Plantations*, *Hospitals*, *Barracks*, etc. :—

1. Removal or protection of all stagnant water in the vicinity.
2. Protection of the windows with wire gauze.
3. Segregation.

C. **Municipal Precautions** to be adopted by *Local Authorities* in towns :—

1. Constant employment of a Mosquito Brigade for draining marshy ground, and removing puddles, rubbish, and rank vegetation.
2. Enforcement of proper sanitary regulations.
3. Cheap sale of quinine.
4. Public lectures.
5. Selection and treatment of cases of malaria.
6. Publication of reliable malaria statistics.
7. Employment of an efficient sanitary service.

The way to prevent *recurrences* of fever after infection will be given in the chapter on Treatment.

XII. Personal Precautions : Mosquito Nets

It will be seen that this list of precautions is divided into three groups—personal, domestic, and municipal precautions. The first can certainly be employed by everyone—except in very rare circumstances.

Perhaps our first and best defence against malaria lies in the habitual and scrupulous use of mosquito nets at night. Long before the connexion between malaria and mosquitoes became known, General Outram, Emin Pasha, and many others attributed their immunity from the disease to their care in this respect. Owing to the same precautions many students of malaria, including

myself, have been able to work in the most dangerous places with impunity. I cannot say enough for the mosquito net. I believe that if all Europeans in the tropics could be induced to use it as carefully as some of us do, malarial infection would be reduced among them to less than a quarter.

In the cities and large stations of India, mosquito nets and punkahs are almost invariably used by Europeans; with the result that, though malaria abounds among the natives in these places, it is hardly known to attack Europeans. But in the planting districts of India and in Africa, nets and punkahs are not nearly in such general use; and it is just in these places that Europeans suffer so severely.

The first care of the resident in the tropics, of the traveller, the sportsman, the soldier, the miner, the clerk, should be for his mosquito net. Wherever he lives, wherever he goes, he should see that his mosquito net is with him, that it is in good order, and that it is properly arranged at bedtime. If the reader neglects this advice—and of course I can only advise—all that I can say is that he is pretty sure to suffer before long.

A person proceeding to the tropics should always take a net with him. If he lands without one, he may acquire a deadly infection the very first night he sleeps ashore.

Never allow yourself to be misled by statements to the effect that there are no mosquitoes in such or such a locality. Read section VII, and put up your net religiously in spite of your 'friends.'

If your house is near a native location, or if you are a traveller and are forced to sleep in a hotel, or in the house of a native, or near a native village, redouble your precautions. It is just in such places that infected mosquitoes most abound.

But it is not enough merely to use a mosquito net—it must be used properly. The following rules should always be attended to :—

Not a single rent or hole in the net should be allowed ; if there is one, mosquitoes are sure to find it out and enter during the night.

The net should be so carefully tucked in under the mattress, or otherwise disposed, that no aperture is left under it.

The mesh should be not much larger than the head of a pin.

When in use the net should be stretched as tightly as possible in all directions, so as to permit every breath of air—so necessary to the comfort of the sleeper in the tropics—to blow through.

Have no entrance in the net; but, when entering, lift the lower edge as little as possible and slip in with a twisting movement, so as to exclude stray mosquitoes which may have been hovering round you outside.

If possible, use a large bed and a large net in order to avoid the hands, feet, knees, and elbows being pushed against the gauze during your sleep, and being bitten through the net by mosquitoes outside. A mosquito *house*, placed round the bed, is good for this reason.

Instruct servants to hang the net before dark, and to see that there are no mosquitoes inside it. If mosquitoes are found inside it in the morning it is due simply to carelessness.

If the bed is furnished with a square frame for the net, hang the latter inside the frame and tuck it under the mattress. Do not place it outside the frame and let it hang to the ground.

Some people say that they are stifled in a mosquito net. This is only because they do not have the net properly *stretched*. Others say that all these precautions

require too much trouble. They require no real trouble at all; in India, every sensible person is most careful in these respects. Why should not people be equally careful elsewhere?

The portable mosquito 'house' is very useful. People who can afford them should have two—one for sleeping in, and the other for reading and writing in (where punkahs cannot be used).

XIII. Personal Precautions: Quinine

As quinine destroys the parasites in the blood, it will prevent their multiplication in the system, even if they do obtain an entry by the mosquito's proboscis. It has been proved by experiments with numbers of soldiers and gaol prisoners that much less fever prevails among men to whom five grains of quinine are administered daily than among those who are not being treated in this manner. But five grains daily is not sufficient to prevent fever entirely; and it is doubtful whether even ten grains daily would suffice for this.

The objection to quinine is that it is apt to upset the digestion and to cause singing in the ears and even deafness. Considering the large degree of protection which can be obtained simply from mosquito nets and punkahs, I do not, therefore, generally advise the habitual use of quinine in malarious places, unless perhaps the reader is one of those persons with whom quinine agrees well.

I do advise the reader, however, to take it as a preventive under the following circumstances :—

1. If he is forced to live in a house where there are, or lately have been, many cases of malaria ; or in the house of a native ; or in or very near a native village—*even if he uses a net with all care.*

2. If he is forced to do without a net; or if he has been much bitten by mosquitoes in spite of his net.

Many methods of taking quinine as a preventive have been suggested. I recommend five grains daily just before breakfast; with a dose of ten grains, instead of the five grains, twice a week. This should be continued for a month and then gradually reduced after leaving the exceptionally malarious place, a strong dose being taken occasionally. If the reader has been much bitten by *Anopheles*, I advise him to take ten grains daily for a fortnight, and then fall back on smaller doses.

If large doses cannot be endured, it is, in my opinion, better to fall back on smaller ones, and to double other precautions, rather than to keep oneself in chronic ill-health in consequence of the drug.

For myself, I rely almost entirely upon mosquito nets.

For some further details, see section XXV.

XIV. Personal Precautions: Punkahs and other Measures

The fact that Europeans enjoy so much better health in Indian towns than they have in Africa I attribute largely to the use of the punkah. Englishmen in India dress, eat, work, and sleep under punkahs —which not only drive off mosquitoes and other flies, but keep the body constantly cool and comfortable. This has the double effect of warding off malarial infection and of retaining the natural energy. In Africa, people sit, sweat, feed mosquitoes, and die.

I strongly advise residents in all tropical countries to follow the Indian example in this and other matters *at any cost*. People in India have learnt by centuries of experience how best to live in the tropics.

I also advise the directors of all business houses and factories to keep punkahs going over the heads of European employés during business hours—as is almost always done in India.

A punkah is a board, or framework covered with canvas, provided with a fringe, and hung by ropes from the ceiling. It is pulled by means of a rope which passes over a pulley and through a hole in the wall. The cost of having the punkah pulled for six hours daily amounts to about twelve pounds a year in Africa and about half that in India. The thing is worth the money.

Electric fans, worked by portable batteries, can now be purchased for ten pounds or so, and, as I have experienced, are a great comfort. They can be used all night, and can be placed wherever required. When British enterprise awakes there will be a large demand for these in the tropics.

I have already warned the reader several times to avoid as much as possible sleeping in the houses of natives or in native villages. In such places native children are almost sure to be present; and as about half of these are likely to contain parasites, a large number of the old mosquitoes living about in dark corners are sure to be infected. In fact, many observers have actually found parasites in a large percentage (up to 25 per cent. or even more) of the *Anopheles* in native houses. A night spent by a European in such without a mosquito net is almost sure to result in infection. Indeed, a man may be thus bitten during a single night by perhaps five or six infected mosquitoes, and may acquire a very severe or even fatal infection in consequence. I cannot impress this fact too strongly on the reader—especially if he be a young man just going to or arrived in the tropics. *Verbum sapienti.* Some

of the worst cases are produced in this manner. *Sleep in a native house often means death.*

Nor are hotels and travellers' rest houses always much better. It often happens that the stranger is ushered into a room which was formerly occupied by a patient, and which may have been kept shut up ever since, full of hungry, infected mosquitoes, which leap upon their new victim the moment he enters. I myself was infected in this manner in a dâk bungalow in India, in 1897.

But it often happens that a traveller is *compelled* to take these risks. What is he to do then ?

If he is forced to sleep in a hotel or rest house, or in a house formerly inhabited by natives, he and his servants should go round the rooms carefully, killing every mosquito they can find. If the rooms can be properly closed, sulphur may be burned in them (section X). If not, it is advisable to flap round the walls and ceiling with a long towel, to shake the curtains, and so on. At night the mosquito net must be used with jealous care, and, if mosquitoes are in evidence, quinine should be taken for some time.

If mosquitoes are numerous in a hotel it is usually *due to nothing else but the ignorance or laziness of the manager.* He should be sent for and told so. One can generally be candid with a hotel-keeper !

The traveller or sportsman should never camp quite close to a native village if he can help it ; still less should he give up his tents to go and sleep in houses lent to him by the headman.

All these remarks apply as much to the prevention of yellow fever and elephantiasis as to that of malarial fever.

XV. Domestic Precautions: Riddance of Mosquitoes

A list of domestic precautions is given in section XI.

It is the duty of the head of a house in the tropics to see that all the inmates use mosquito nets at night.

He should also have punkahs slung in the sitting-rooms at least; or, failing these, purchase one or more electric fans.

He should make it his principal duty to see that no mosquitoes are breeding anywhere within his premises. This is an easy task. After having carefully read section X, he should make it a rule to go round the whole of his house once a week—say on Sunday morning—in order to look for mosquito larvae or stagnant water. He should search every nook and cranny of his garden, backyard, servants' quarters, latrines, kitchen, stables, and sitting and sleeping rooms. Every broken bottle, empty sardine tin, broken floor pot, etc., should be placed in the dust-bin or in a large box (with a lid), to be removed by the scavenger or, if there is none, to be buried or otherwise disposed of. Cisterns, tubs, gutters, wells, pits, drains, should be looked to. If they contain larvae, these should be destroyed by oil or by sweeping them out, or other means; and then steps should be taken to preserve such water as is really required for household purposes by mosquito-proof covers.

In my experience (a large one) a weekly round of this kind serves to keep a house nearly free of mosquitoes, even if they are breeding in the neighbours' houses. It also does good by stimulating the servants to keep the whole place clean.

For further details see section X.

XVI. Domestic Precautions: Wire Gauze Screens

If mosquitoes continue to abound in the house in spite of these measures; if there are many breeding pools or much bush in the vicinity, which it is impossible to get rid of, then wire gauze screens should be applied to the windows. In many localities, in isolated houses situated in the middle of forests or by the side of extensive marshes, this measure will often be the appropriate one. I think that it should also be employed in houses placed near the locations of natives, and in barracks and hospitals—at least unless the local authorities are actively and successfully extirpating mosquitoes on a large scale.

Wire gauze can be purchased from many manufacturers (see advertisements). Brass or copper gauze will last longest; but it has been found in Lagos that tinned iron gauze lasts a long time; and it is cheaper. It is impossible to give full details here regarding the mode of protecting the house by this means, because every house differs so much in regard to the fastening of its doors and windows; the reader must make the arrangements for himself. One important principle must be closely attended to—not a single aperture must be left unprotected; ventilators, and even drains, must be guarded. For doors, I think it will suffice, as a rule, to provide an automatic shutting arrangement. For English sash windows (*i.e.*, windows which slide up and down) it will generally do merely to nail up the gauze outside. For French windows (*i.e.*, hinged windows which open outwards) it will generally be necessary to make similar windows furnished with gauze instead of glass, opening inwards. In many instances, however, it will be possible merely to replace the glass with gauze.

In the tropics this gauze is not at all unpleasant. I found in Lagos, contrary to my expectations, that it does not shut out the breeze. On the contrary, it allows every breath of air to pass through it, and at the same time excludes flies, wasps, beetles, and moths, as well as mosquitoes. In short I recommend all who can afford it to screen their houses with wire gauze—or at least certain rooms in the house. This thing is constantly done in the Southern States.

Unfortunately, this measure is likely to be adopted only by the owners of houses. The majority of Europeans in the tropics are merely monthly tenants of houses owned by rich natives and others. In such cases neither owner nor tenant is likely to go to the expense involved.

It would pay local trading companies in tropical towns to undertake house-screening as a part of their business. The comfort of life would be largely enhanced by the measure—at least if punkahs or electric fans are employed as well.

XVII. Domestic Precautions: Segregation, etc.

One of the chief reasons why Europeans are more healthy in India than in some other tropical countries, is, I think, because in India they generally live in separate quarters. In locations where the houses are surrounded by large gardens, infected mosquitoes are not likely to be so common as in houses surrounded by a poor and crowded native population.

Unfortunately, where separate European quarters do not already exist it is as a rule impossible for individuals to segregate themselves without going out into tents. It is to be hoped, however, that the governments

of our tropical colonies will exert their influence gradually to segregate the Europeans after the Indian fashion.

In trading centres, much can be done by the owners of factories, etc., by buying out and removing the huts of natives from among the houses of the European employés. It is questionable, however, whether the money could not be generally better spent in keeping the whole surrounding area free of mosquitoes.

Rank vegetation should always if possible be cleared away from the vicinity of houses, as it is very apt to harbour mosquitoes. Large trees are good at some distance from a house, but not close by. I dislike flowers being kept on the verandah, and am not partial to luxuriant tropical gardens, irrigated from numerous wells and cisterns. Better have an open grassy 'compound.'

The Indian house, with its spacious, airy rooms and whitewashed walls and ceilings, and its large compound and distant servants' quarters, is the ideal to be always approached. Compare with this the damp wooden shanties of Sierra Leone, crowded together and opening directly on the street, and we shall understand why the latter place has been called 'the white man's grave.' Mosquitoes love damp and dark rooms as much as they hate light and airy ones.

XVIII. Factories and Plantations

The rules for keeping these free of fever are simply those already given, and may be summed up as follows :—

The European employés must sleep in mosquito nets. Punkahs or electric fans should be freely provided. All stagnant water should be removed for some distance round, or should be protected against mosquitoes. If

this cannot be done, or if it does not suffice, the windows should be thoroughly screened with wire gauze. The quarters of native servants or employés should be placed at a distance. Rank vegetation should be cleared. Infected employés should be thoroughly treated with quinine.

In large isolated factories I recommend that two or three intelligent natives be constantly employed in keeping the whole place free from mosquitoes—in draining and filling up puddles, clearing watercourses and ponds, and so on. The cost of labour in the tropics is generally only about twelve pounds per annum per head; and two or three men will work wonders even in a few months. Where several factories are placed close together they should combine to maintain an effective 'mosquito brigade' under the supervision of one of the European employés.

The same principle should be employed for hospitals, barracks, gaols, etc.

XIX. Municipal Precautions

This is a very large subject, and cannot be studied in this little work—which aims at helping only the individual; but full details will be found in my work on *Mosquito Brigades*.

That work also contains full accounts of the anti-malaria campaigns carried on at Hong Kong and New York; by Sir William Macgregor and Dr. Strachan at Lagos; by the Liverpool School of Tropical Medicine and Sir Charles King Harman at Sierra Leone; and by the Americans and Major Gorgas in Havana. In the last place malaria has been reduced to a half, yellow fever has been banished, and mosquitoes reduced by 90 per cent.

A similar campaign is just about to be started by the Government of the Gambia in Bathurst, where Dr. Dutton, of the Liverpool School of Tropical Medicine, has studied the disease-bearing mosquitoes; and by the Governor of the Gold Coast, Major Nathan, assisted by a delegate of the same School, in that Colony. And I venture to say that in a few years active operations against malaria will be undertaken in all the malarious towns of tropical British or American possessions.

I advise all influential people in such towns to help towards this end by urging upon their local governments the necessity for undertaking these operations. For instance, those who are annoyed by mosquitoes coming from outside their own premises should complain to the municipality. If the municipality takes no action, a few intelligent people can easily raise a subscription and hire a gang of men to keep down the mosquitoes in their neighbourhood—as described in the book referred to.

XX. Futile Precautions

The idea that malaria is caused by a miasm which rises from marshes and the ground, baseless as it is, has given rise to a number of precautions which are not only useless but actually prejudicial to the health of those who adopt them. Impelled by this old superstition—and it is nothing more—many people do the most outrageous and unnatural things in the hope of escaping infection. Some swaddle themselves in flannel in the hottest weather. Others refuse to go out in the cool of the evening for fear of the 'malarial mists'—regardless of the fact that if the germs are in the air outside a house, they are sure to find their way into the air inside the

house as well. Others shut up all the windows directly there is a cooling breeze; others refuse to take exercise, and die of 'liver' for fear of dying of fever. Others again think that they can exclude the germs by means of alcohol. A man once informed me that he got his fever from eating pineapples; another that he was sure to have an attack if he had forgotten to say his prayers overnight! A common notion appears to be that in order to escape the disease one must do the most unnatural things it is possible to do.

Needless to say, the reader should throw such ideas to the winds. Wear as light flannel clothing as is comfortable or possible; but always change after exercise. Join in every out-door sport, and take as much exercise as you can. Enjoy every breeze that blows, and be in the open as much as possible. Eat and drink in moderation. Take only those precautions which science enjoins, and in other respects live as naturally and healthily as you can.

Chapter IV

TREATMENT

XXI. Preliminary Hints

When a person has become infected with malarial fever, he must obey the two following golden rules :—

1. **Send for the doctor.**
2. **Do as he orders.**

I may as well take the opportunity to inform the reader of a fact which, perhaps, he does not know. Unless he is a doctor—well, he is not a doctor. Even if he has taken the trouble to read this book, he has not thereby become an accomplished physician. To speak plainly, if he is sick he had better abandon the notion that he can treat himself as well as the doctor can.

Another hint—which the patient will find really invaluable. Do not distrust the physician, whoever he is ; do not argue with him ; do not question the correctness of his diagnosis and treatment ; do not fancy that you cannot take this or that medicine. I can simply assure the reader that physicians much prefer having to treat a sensible man with a severe illness than a fool with a slight one. Merely state the **facts** about your case and **obey.**

Everyone should be taught how to *prevent* disease, because everyone can understand the simple rules required for the purpose. But it is not necessary—not even advisable—to teach everyone how to *treat* disease ;

because the treatment of disease is an exceedingly complex matter, requiring a specially trained intellect for dealing with it.

An exception to this rule must be made in the case of malarial fever, but only for one reason, namely, that the disease occurs so frequently in places where there are no medical men. But even here, I shall give only a few leading rules for adoption by the lay reader so long as he cannot procure professional advice. When he can do so he must avail himself of it and *shut this book*.

XXII. Diagnosis

As an example of the difficulties which beset the treatment of disease, I should mention that in the first place none but skilled medical men can be relied upon for making a trustworthy diagnosis. Thus, as regards malarial fever, Crombie has made out a list of some *twenty fevers* which may be mistaken for it. It is sometimes impossible even for experts to distinguish the true nature of a given case of fever; and, if this is true for experts, the layman is likely to be much more at fault.

There exists indeed one quite reliable method of determining that a case of fever is malarial; and that is by taking a drop of blood from the patient's finger and finding the parasites in it by means of the microscope. But this can be done only by the practised physician; the layman must depend upon much more uncertain data.

The illness is likely to be malarial fever under the following circumstances:—

1. If the fever comes on suddenly without any previous local symptoms, such as continued pain in the

stomach or chest, diarrhoea or dysentery, abscess, inflamed wounds or sores, large boils, persistent cough or cold in the head, and great weakness of the legs.

2. If it *begins* in a locality known to be very malarious, or from five days to some weeks after the patient has been in such a locality.

3. If, after the fever has lasted for some days, the temperature suddenly falls below normal (say to 97° F.) and then suddenly rises again. If this story is frequently repeated; and especially if the fever recurs regularly every day, or every other day, or every third day, or at irregular intervals, then the disease is *almost certainly* malarial fever.

4. If the fever leaves off after large doses of quinine have been taken regularly for several days.

The fever is *possibly* not malarial if it has been preceded for some days or longer by any of the local symptoms mentioned in (1). It is *probably* not malarial if it lasts for one week without a complete break occurring spontaneously (that is, without the use of such drugs as antipyrin, antifebrin, and phenacetin). It is *very probably* not malarial if it continues for more than a week in spite of large and continuous doses of quinine.

It is *almost certainly* malarial if no source of local irritation exists and if numerous breaks occur, followed by recurrences, especially if the fever recurs every other day (tertian fever) or every third day (quartan fever).

The other fevers most commonly found in malarious localities are typhoid or enteric fever, Malta or undulant fever, and several other varieties, some of which are called sun fevers and ephemeral fevers. All these tend to differ from malarial fever in that they are *continued fevers*—that is, as a rule, they do not have a complete break (with a temperature below 98° F.), followed by a

recurrence. Typhoid and undulant fever generally last for three weeks or more without a complete break ; so do several other tropical fevers. The so-called ephemeral and sun fevers usually last only for a day or two, and do not recur. If fevers supposed to be such do recur, it is not unlikely that the patient is really suffering from malaria. It often happens, especially if the patient has been taking much quinine as a preventive, that the attacks of malarial fever are slight and separated by long intervals, and are then mistaken for sun fever. *The keynote of malarial fever is recurrence.*

Fortunately the amateur physician is often saved the necessity of making a definite diagnosis by the following rule :—*If the fever commences in a malarious locality, or shortly after a visit to one, it is, on the whole, safest to treat it as if it were certainly a malarial fever.* This will do no harm, even if the illness ultimately prove to be not malarial, and may save the patient's life if it prove to be so.

Another important rule is this one :—*If the fever does not yield after a week's anti-malarial treatment, try to get a doctor at all cost.*

XXIII. How to Use the Clinical Thermometer

Wash the thermometer in cold water ; shake down the register by a series of jerks ; place the bulb under the tongue ; shut the lips (but not the teeth) on the instrument, keeping them so for three minutes, and breathing through the nose. Then read the temperature.

If the patient's teeth are chattering in an ague fit, the bulb must be put into the armpit.

The *normal temperature* is put roughly at 98·4° F.; but as a matter of fact the temperature varies in health about half a degree above and below this, and is different

in different people. After hot tea or soup the temperature of the mouth may be considerably raised.

A temperature of 104° F. or above is *high fever;* and below 97° F. is *subnormal.* The malarial temperature frequently touches both extremes. The temperature of most other fevers seldom goes naturally below 99° F. It must be remembered that antipyrin, antifebrin, and phenacetin may bring down the temperature artificially for some hours.

XXIV. Fundamental Principle of Treatment

This is based upon the following facts:—

1. Malarial fever is caused by multitudes of parasites, which live indefinitely in the blood.

2. The object of treatment is to exterminate these parasites entirely—not merely to reduce their numbers temporarily.

3. Quinine taken constantly in considerable doses for three or four months generally exterminates the parasites, provided that reinfection does not occur.

The good effect of quinine and cinchona bark (from which quinine is made) in malaria has been known for centuries, and is quite assured. But the drug is often discredited because it is not used properly. It is often taken in doses which are too small to be effective; and, what is still worse, it is often left off much too early. What frequently happens is this. The patient takes quinine while he has fever. As soon as it has destroyed a large number of parasites, his fever abates and—he remits the quinine. The parasites increase again, and after a some days or weeks a relapse comes on. He again takes the quinine, and again drops it; with the same result. And the same story is

repeated again and again, until the patient becomes a wreck, and at the same time loses his faith in quinine!

The first rule of treatment is this. *If a person has once become infected with malarial fever he must continue to take quinine regularly for at least three or four months*, **whether he gets fever or not.**

The parasites in man are like rats in a ship: you may destroy numbers; but if you leave even a few alive they will breed again and become as numerous as ever. Quinine, like rat poison, must be used to exterminate, not merely to reduce.

Hundreds of drugs have been recommended for malaria. Many reduce the fever temporarily; but to reduce the fever is not to remove the infection. For removing the infection quinine is the only drug the efficacy of which is generally accepted; and even this is not permanently effective unless its use is continued long enough.

XXV. How to take Quinine

Quinine is a white powder which does not dissolve in plain water. But it will dissolve if a few drops of dilute sulphuric acid (medicinal) or of dilute hydrochloric or acetic acid be added to the water. Or it can be shaken up in plain water by means of a fork; or taken in the shape of tabloids, capsules, or pills.

Quinine is wanted in the blood and not in the stomach; and the form in which it most rapidly enters the blood is when it is taken dissolved in acid. The next best form is that of the powder shaken up in water. In my opinion quinine in pills, tabloids, and capsules takes longer to be absorbed and irritates the stomach more. The presence of the drug in the blood is announced by the familiar 'singing in the ears.'

Pills and tabloids are very apt to harden in the tropics ; in which case they may pass through the intestine without being absorbed at all. They should not be used unless they break up easily after being immersed for a few minutes in water.

The objection to taking quinine in suspension or solution is the intensely bitter taste which it leaves in the mouth. This can easily be avoided by taking one or two mouthfuls of food, such as bread and butter, *immediately* after the medicine.

The best time to take quinine, either for prevention or cure, is just before meals—especially before breakfast. Prepare the suspension or solution in a wine-glass ; place it at your side ; prepare a mouthful of food ; then swallow first the quinine and the next moment the food. The taste of the drug will vanish in an instant ; and within half-an-hour a ringing in the ears will announce that the quinine has entered the blood. Moreover, the digestion is little affected. On the other hand, pills or tabloids taken on an empty stomach often cause a most unpleasant feeling for hours. I suppose that the solution or powder is absorbed almost immediately ; while the pill or tabloid lies for a long time in the stomach, slowly dissolving in the gastric juice and irritating the mucous membrane.

Tabloids have the advantage of containing measured doses. It is very good to break them up in water and dissolve them with a little acid.

Chemists sell concentrated solutions ready for use with the addition of water.

Some people really cannot take quinine, others fancy they cannot, and others again really object only to the taste. The drug is borne best in the morning, before food, and when the bowels are acting properly.

Koch is of opinion that quinine may excite attacks

of blackwater fever. Unfortunately, his views have been much misrepresented, with bad results. As a matter of fact, he is strongly in favour of the *continuous* use of *moderate* doses of the drug in malarious localities. What he objects to is the *sudden heroic* dose taken by infected persons who have left off quinine for a long time and then determine to begin it again. It is this procedure which he thinks may bring on blackwater fever. It is in any case a wrong procedure.

XXVI. Details of Treatment: The First Week

Of course the trained physician possesses a number of weapons in his armoury besides quinine; but it would be folly for the amateur to attempt to use all of these. I advise him to keep as much as possible to the quinine, and to leave the patient's constitution to deal with details. He should remember the following maxims:—

Do not be alarmed.
Do not constantly meddle with symptoms.
The vast majority of malarial attacks get better of themselves.

Suppose then that the reader is called upon to treat a case of fever, say himself, in the absence of a doctor—what should he do?

Let us suppose that the patient is an adult European, and that he is suffering from his first attack of fever.

Give him ten grains of quinine about every twelve hours for a week.

This treatment should be commenced at once, whether the patient has high fever or no, whether he is being constantly sick or not. It is bad policy to wait. Give him ten grains of quinine as soon as you have

determined, to the best of your ability, that he should have quinine at all (see section XXII). The old idea was to wait until the fever abates ; but this is not sound. The same rule should hold with regard to subsequent doses.

There is a difficulty when the patient vomits the medicine—as indeed often occurs. If he vomits it within half-an-hour of taking it, wait five minutes and then give him another ten grains of quinine. If he vomits after half-an-hour, but within two hours, give him five grains instead of ten.

If you think that the patient can stand larger doses, give him fifteen-grain doses instead of ten grains. Do not give less than twenty grains a day for a week, unless you find it absolutely impossible, owing to the patient's resistance ; and then reduce the dose as little as possible.

In giving quinine, remember the instructions of section XXV.

It is often useful to administer a smart dose of a purgative with the first dose of quinine. Saline purgatives, such as Epsom salts (one table-spoonful or more in hot water), or a seidlitz powder, or other quickly-acting effervescing saline, are best.

After the purgative has acted, twenty drops of tincture of opium (laudanum) will be soothing. This may be repeated once daily for one or two days until the patient is under the full effect of the quinine.

If the patient feels very cold during the rigor, heap blankets on him, and even give him hot-water bottles—but no spirits. Hot tea without milk or sugar is good, both during this stage and for controlling vomiting.

When, a few hours later, the fever is at its height; when the skin is hot and dry and refuses to perspire, a cup of scalding hot tea, coffee, or soup, or

a large glass of whisky or brandy and soda water will often do much good.

When sweating is well forward and the temperature is falling down to normal, give some food; and, just before you give it, *try and smuggle in an extra five grains of quinine.* In fact, try to get your patient to take up to thirty grains of quinine daily during the first week.

While the fever lasts, the diet should consist entirely of *soft* food, such as broth with bread or boiled rice; bread and butter; and if milk is available, milk and soda, custard puddings, rice and sago puddings. If, however, the temperature falls *below* normal and the patient feels hungry, I am not averse to giving a little minced fowl and boiled rice or mashed potatoes—if possible preceded by a little quinine. If the temperature remains below normal for twelve hours or more, a still more liberal diet can be given.

I do not advise the frequent use of antipyrin, phenacetin, and antifebrin. These reduce the fever, it is true; but the reduction is only temporary; and I have seen records of cases in which the illness lasted for weeks *until the phenacetin was stopped.* Ten grains of phenacetin when the fever rises above 105° F., and only then, may however be safely recommended; but a cup of hot broth or tea may do as much good.

Do not be constantly worrying about the state of the bowels.

Even when the fever ceases after the first day, still continue to give at least twenty grains of quinine for a week.

The treatment of native patients is much the same; but they will generally throw off the fever much more readily than Europeans will.

XXVII. Treatment after the First Week

If the fever has left off during the first week, or has broken into separate attacks (section II), the quinine may now be reduced to fifteen grains daily, ten before breakfast, and five before afternoon tea or dinner. But it is better, if possible, to continue the twenty grains for at least another week, and then to reduce it gradually.

If it is almost certain that the fever is truly of a malarial nature, the following system of medication should be adopted, or at least approached :—

1. For the first fortnight, twenty grains daily.
2. For the second fortnight, fifteen grains daily.
3. For the second month, ten grains daily.
4. For the third month, five grains daily; with ten grains instead of the five grains, at first twice a week, and then once a week.
3. For the fourth month, ten grains once a week, and one or two five grain doses on intermediate days.

If during this period a relapse occurs, start again from the beginning.

Remember it is possible to give here only general rules. Some patients require less and others more quinine. If fever returns in spite of the doses advised, larger ones must be given.

If in spite of all treatment several relapses occur, it is perhaps best to send the patient home to Europe, *to undergo thorough treatment there.*

If after the first week the fever continues *without a single break* in spite of twenty grains of quinine a day, the case is very probably *not malarial at all.* Adopt the following measures :—

1. Continue the twenty grains of quinine.

2. Try to get a doctor.
3. Give only the softest foods—milk if possible; or milk puddings; and broth and soft bread, or boiled rice.

If in spite of treatment the fever continues without a break for a fortnight, the case is almost certainly not malarial, and may be typhoid, or undulant, or hyperpyrexial fever. Reduce the quinine to five or ten grains a day; give soft food, and do your best to get a medical man.

XXVIII. Treatment of Old Cases

The reader may be called upon to treat a patient who has had several previous attacks, and now has a relapse (section II). Whether he has taken quinine or not, the treatment is practically the same. He must have the parasites in his blood, and they must be exterminated. Put him through a three or four months' course of quinine.

It is, however, necessary to use one precaution. Do not commence suddenly with twenty-grain doses of quinine daily. Begin with only five grains daily for a week; then increase this to ten and twenty grains for the second and third weeks, and afterwards proceed as in other cases. This is for fear lest sudden large doses should bring on blackwater fever.

If the case is a very old one, if the patient has been having fever on and off for months, it will, perhaps, suffice to work up daily doses of only fifteen or even ten grains. But the medicine must be continued for months.

If the patient is very sallow and anaemic and has a large spleen, five grains of quinine daily, with an occasional dose of aperient mineral water, and plenty of fresh milk or other good diet are called for. Such cases

will generally be found among natives, for Europeans usually leave the tropics before this stage is reached. Even with Europeans, however, five grains of quinine daily for some months will work wonders at this stage.

Complete recovery is possible at all stages of malarial disease.

XXIX. Treatment of Children

This is conducted on the same lines, only all the doses of medicine must be reduced *in proportion to body-weight.* The doses of quinine given above are for a man of about one hundred and fifty pounds in weight. Hence for a child of fifty pounds in weight only one-third these doses would be required ; for a youth of one hundred pounds in weight, two-thirds the amount, and so on.

The youngest children can easily be persuaded to take quinine daily before breakfast if a little patience and tact be employed. It generally agrees wonderfully with them. From one to two grains usually suffice.

It should be remembered that very small children and even infants frequently have malaria in the tropics ; but the symptoms are often not a little disguised. Thus, instead of the severe and continued attacks from which adults suffer, children often show only a few slight rises of temperature accompanied by anaemia, peevishness, and enlarged spleen. Of course the fever is often overlooked. Native children full of parasites may be seen running about apparently quite well.

XXX. General Management of Cases

People seldom remember that in places where they receive one infection, they may receive many. For instance, where a man is bitten by an infected mosquito

on one night, he may be bitten by numerous infected mosquitoes on subsequent nights; and may thus receive dose after dose of the disease. More than this, a patient who does not carefully guard against bites and does not destroy his parasites with quinine, may *reinfect himself*, by infecting surrounding mosquitoes which some weeks subsequently inject the poison back into his blood. There is no doubt of this; and it is obvious that careless persons may end by acquiring very severe malarial fever in this way.

Hence all patients suffering from malarial fever must not only endeavour to rid themselves of parasites but must take the most stringent precautions against being bitten by mosquitoes—partly to escape reinfection, and partly to avoid infecting surrounding mosquitoes and thus infecting other people living in the same house.

In a house or factory containing many persons, if one of these is attacked with malarial fever although he has not slept elsewhere for three weeks, it is most probable that other persons will soon be similarly attacked, owing to some neighbouring source of infected mosquitoes. Where one person has been infected it is probable that others will be. It is therefore advisable for the whole household to begin taking quinine as a preventive, and to redouble precautions against mosquitoes. I advise, also, that one or more natives should be employed in killing all the mosquitoes which they can find about the house in the early morning.

Persons who have once been infected are often very susceptible to chill, cold wind, and damp; and also to the heat of the sun. This generally shows that they still have numerous parasites in their blood. Under such circumstances it is better to adopt an exterminating course of quinine than to swaddle oneself in flannel and take no exercise.

It is no use worrying oneself over a hundred details of food, clothing, and the like ; and refusing to go out in the evening, and so on. The old ideas about the wonderful influence of the personal constitution, so much in vogue years ago, are now much discredited owing to the precise and definite discoveries of modern pathology. Certainly personal constitution is of some importance; many men and animals take given diseases more or less readily than the majority do. But my advice to a person suffering from malarial fever is (in the absence of a doctor) to leave his constitution alone and concentrate his efforts on getting rid of his infection.

After the severe fever has passed off, diet is not of much consequence. In diet, as in clothing, exercise, and alcohol, a sensible moderation is what is required.

XXXI. Prevention and Treatment of Blackwater Fever

As mentioned in section II, blackwater fever is practically a dangerous symptom which sometimes intervenes during a relapse in old and neglected cases of malarial fever. Koch thinks that it may be excited in cases of this kind by sudden large doses of quinine (section XXV). There is much to be said in favour of this view, although blackwater may occur in persons who have not taken quinine at all.

In order to prevent blackwater fever, *prevent infection*, or *get rid of your infection*, and *prevent reinfection*.

Do not let yourself become 'an old case' of malaria. As Koch himself advises, if you do happen to become infected, take quinine constantly until the infection is conquered ; but do not leave it off for weeks or months

and then, in a fit of repentance, take a 'whacking dose.' This is not the way to remove infection ; but it may quite possibly be the way to bring on blackwater fever.

If an attack of blackwater does come on, it has to be treated. Here I am met by a great difficulty. There is no royal road to treatment in this complaint. Indeed, a bad case of blackwater calls for the greatest skill of the most experienced physician and the most careful nurse. Every medicine given, every remedial measure employed, must be suggested by the subtle perceptions of the trained clinician. It is not only impossible to convey instructions on this point to the amateur, but any effort to do so would only plunge him into a host of difficulties, to the detriment of the patient. I content myself, therefore, with advising the following course of action, which, after careful thought, I think is the safest to be prescribed for use by non-professional persons who may suddenly be called upon to do their best for a case of this often terrible complaint.

1. If the urine is merely of a dark yellow, or even of a dusky orange, with or without sediment, there is no reason for supposing it to be blackwater.

2. If, however, there is a distinct tinge of red in it ; if it is claret coloured ; if it is blood red ; or red black ; it is blackwater.

3. As soon as blackwater appears, put the patient to bed and stop quinine.

4. Give a moderate dose of some effervescing saline purgative.

5. Give no other medicine. Do not worry the patient with mustard plasters. If he is fairly strong and his temperature is over 104° F., he may try a warm bath, stopping in it for ten minutes. For vomiting, which is almost sure to occur, hot tea without milk and sugar is often very soothing. If he feels cold he may have hot

water bottles placed round him. The warm bath may be repeated if it agrees well with the patient.

6. The diet should be a few mouthfuls of broth every two hours while the fever lasts. Do not hope to 'keep up his strength' by stuffing him with all kinds of foods, which, as a matter of fact, he will not digest. Nor do I advise constant doses of alcohol.

7. Remember that nature may be a better physician than you are.

8. Jaundice is almost sure to appear after a few days, and may be left alone.

9. It is a bad sign if the urine becomes very black or very scanty.

10. After he recovers (if he does so) wait for several days, and then commence to give him quinine, very cautiously, before meals. Begin with not more than five grains daily (in two doses of two-and-a-half grains each), continued for a week. If he bears this well, increase the dose gradually up to ten grains daily; and then proceed as laid down in section XXVII. *Let him see a medical man as soon as possible.*

It is scarcely advisable for those who have once had blackwater fever to return to the tropics—at all events to countries where blackwater abounds.

XXXII. Note on Camps

In the case of camps which are moved from day to day, it is useless to attempt drainage or destruction of mosquitoes, and we must fall back upon mosquito netting and quinine. The careful traveller will probaby be largely repaid if he makes arrangements to protect his whole party, carriers and servants included, by nets. It is easy to devise methods for making tents mosquito-proof; and details can safely be left to the reader's

ingenuity. Care must be taken that the netting is not torn or tilted by ropes, poles, and baggage. A large package of spare netting should be provided for use when the old netting wears out. I fancy that it would also be good to take one or more large portable 'mosquito houses' for the party to sit in in the evening in places where gnats are numerous.

Rules are often laid down for the selection of sites for camping; but these are generally inoperative, owing to the exigencies of travel. It is, perhaps, not necessary to insist much on the avoidance of marshes—though, of course, this is useful where practicable. On the other hand, *the camps should never be pitched within half-a-mile of a village*, if this can be avoided.

Frequent prophylactic doses of quinine to the whole party are always demanded; and patients should be energetically treated, especially in stationary camps.

The same rules should be used for soldiers on the march—as is done by the Americans in the Phillipines. This is of the utmost importance as a State matter; and it is to be hoped that our authorities will shortly begin to see to it.

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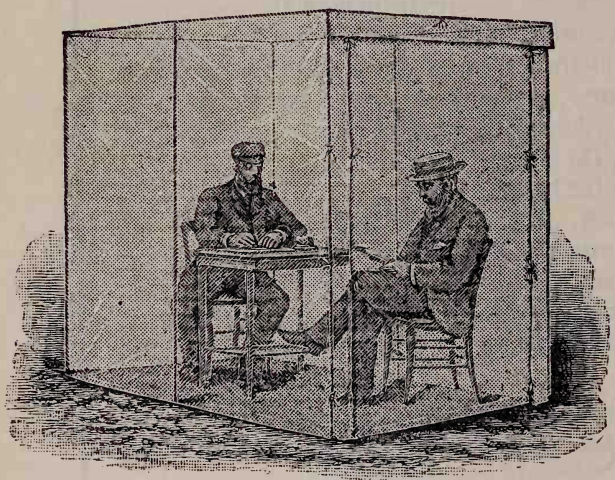

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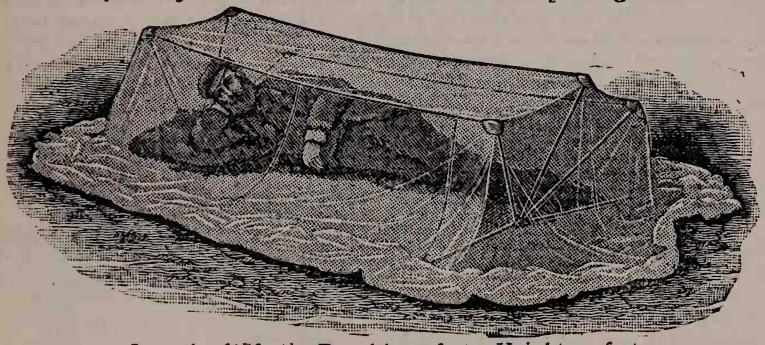

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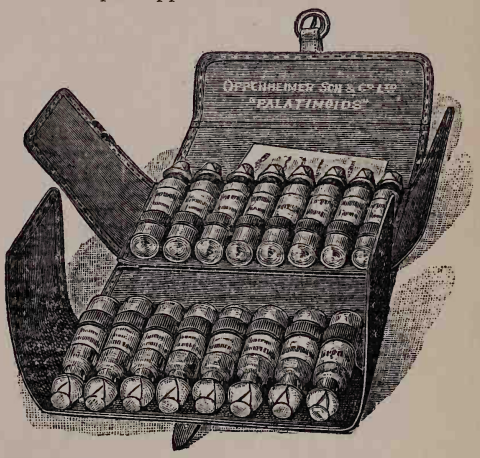

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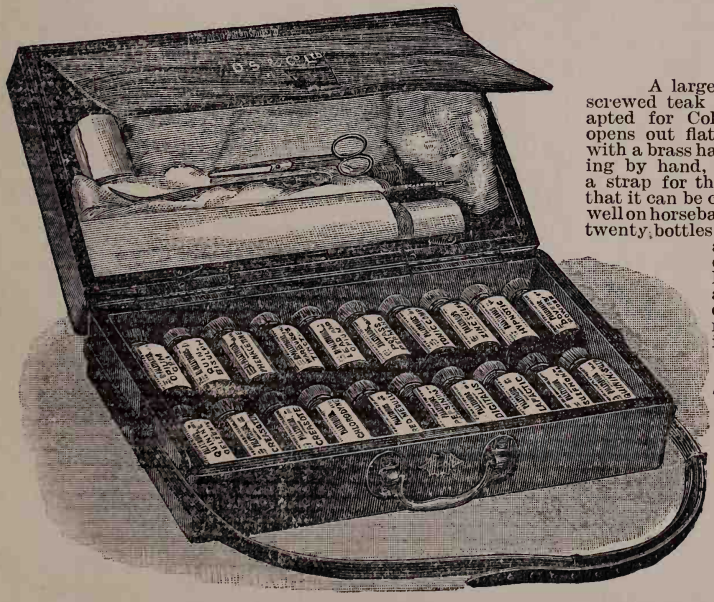

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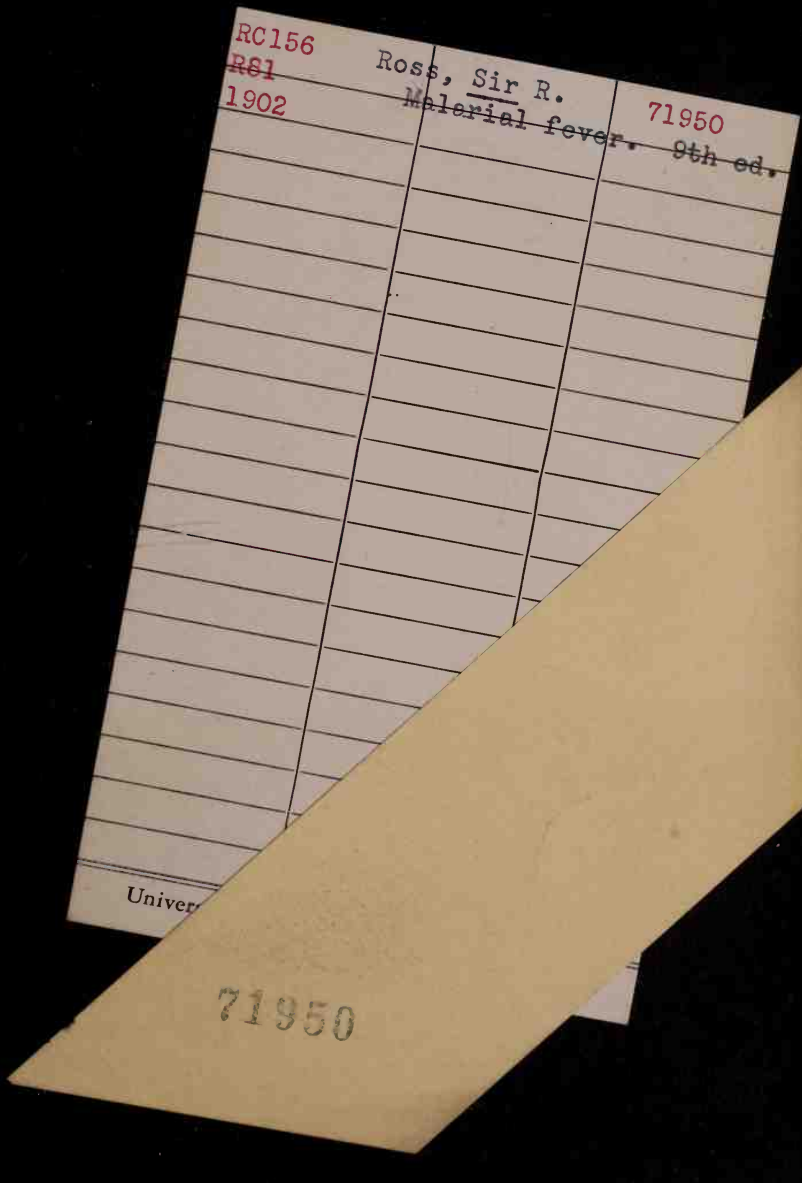
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